The Large Water Detector project for DUSEL

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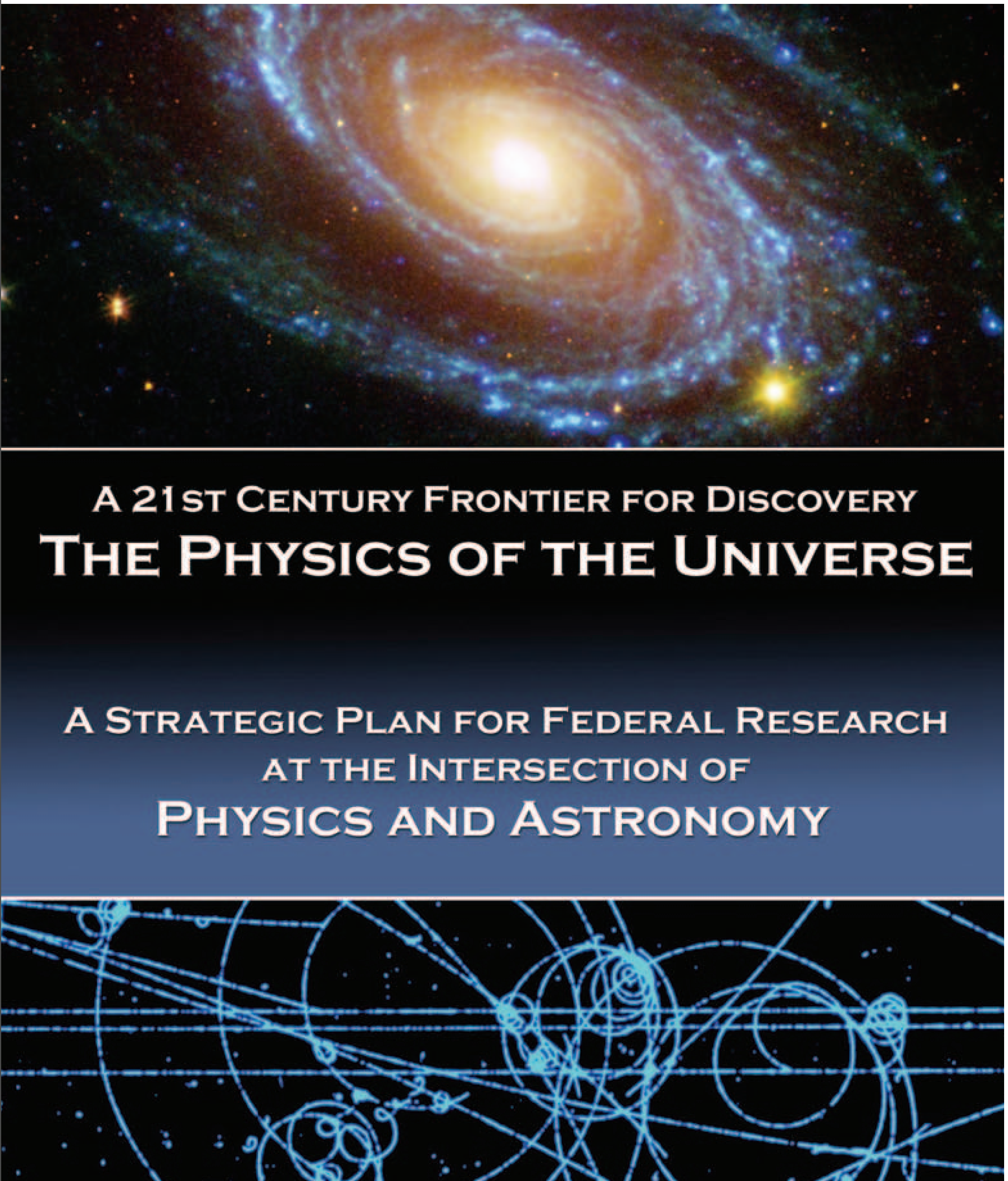
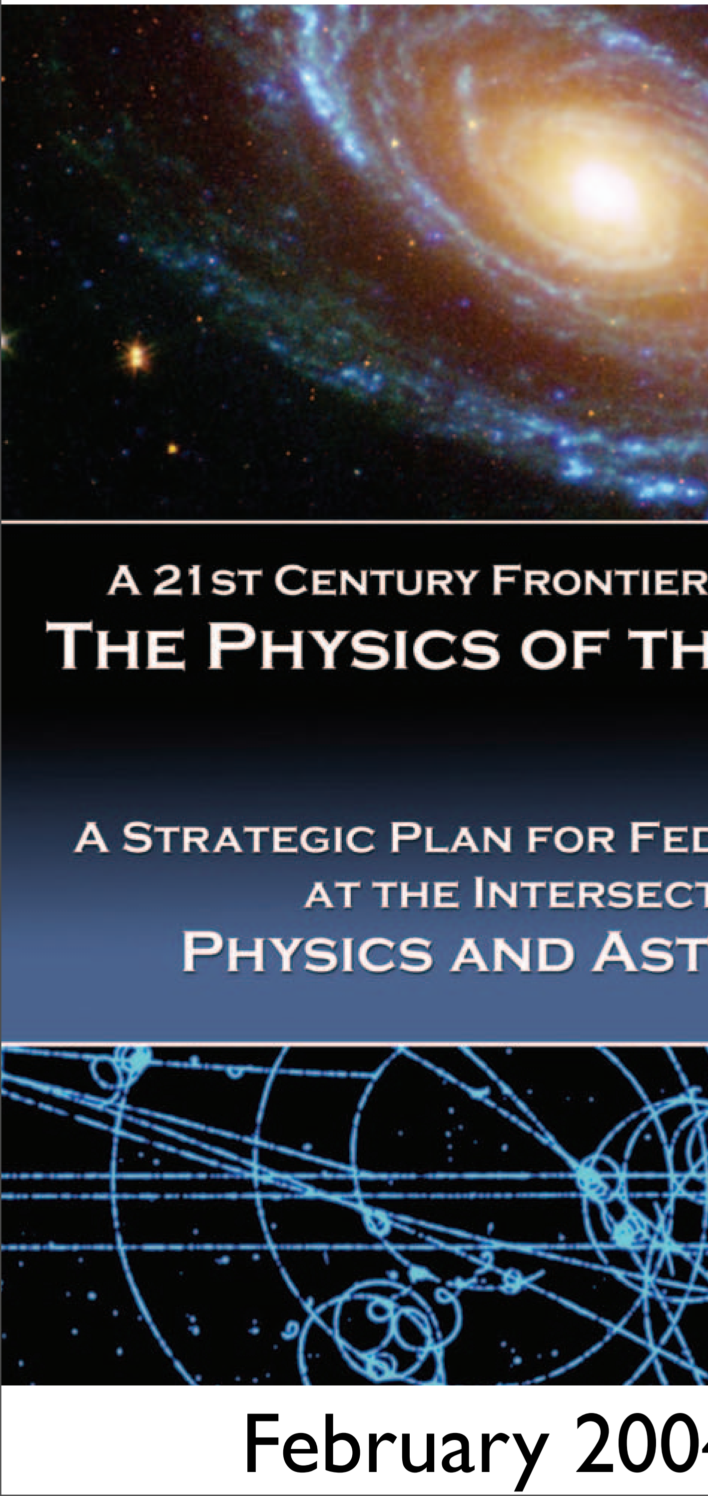
Chicago

Project

- Project plan is extremely preliminary. It has not been reviewed.
- Many items need to be backed up or recosidered.
- How it fits into the overall DUSEL plan is uncertain.
- I am going to show one version that has been developed.



February 2004



Ready for Immediate Investment and Direction Known

Dark Energy

* NASA and DOE will develop a Joint Dark Energy Mission (JDEM). This mission would best serve the scientific community if launched by the middle of the next decade. Studies of approaches to the JDEM mission undertaken now will identify the best methodology.

* A high-priority independent approach to place constraints on the nature of Dark Energy will be made by studying the weak lensing produced by Dark Matter. This is a scientific goal of the ground-based Large-aperture Synoptic Survey Telescope (LSST). Significant technology investments to enable the LSST are required, and NSF and DOE will begin technology development of detectors, optical testing, and software algorithms leading to possible construction with first operations in 2012. NASA will contribute their expertise as appropriate.

* Another priority method to constrain Dark Energy will be to use clusters of galaxies observed by ground-based Cosmic Microwave Background (CMB) and space-based X-ray observations. A coordinated NSF and NASA effort using this technique will provide independent verification and increase the precision of the overall measurements.

Dark Matter, Neutrinos, and Proton Decay

* NSF will be the lead agency for concept development for an underground facility. NSF will develop a roadmap for underground science by the end of 2004.

* NSF and DOE will work together to identify a core suite of physics experiments. This will include research and development needs for specific experiments, associated technology needs, physical specifications, and preliminary cost estimates.

Gravity

* NSF, NASA, and DOE will strengthen numerical relativity research in order to more accurately simulate the sources of gravitational waves.

* The timely upgrade of Laser Interferometer Gravitational wave Observatory (LIGO) and execution of the Laser Interferometer Space Antenna (LISA) mission

Next Steps for Future Investments

Origin of Heavy Elements

* DOE and NSF will generate a scientific roadmap for the proposed Rare Isotope Accelerator (RIA) in the context of existing and planned nuclear physics facilities worldwide.

* DOE and NSF will develop a roadmap that lays out the major components of a national nuclear astrophysics program, including major scientific objectives and milestones, required hardware and facility investments, and an optimization of large-scale simulation efforts.

Birth of the Universe Using Cosmic Microwave Background

* The three agencies will work together to develop by 2005 a roadmap for decisive measurements of both types of CMB polarization. The roadmap will address needed technology development and ground-based, balloon-based, and space-based CMB polarization measurements.

High Density and Temperature Physics

* In order to develop a balanced, comprehensive program, NSF will work with DOE, NIST, and NASA to develop a science driven roadmap that lays out the major components of a national High Energy Density Physics (HEDP) program, including major scientific objectives and milestones and recommended facility modifications and upgrades.

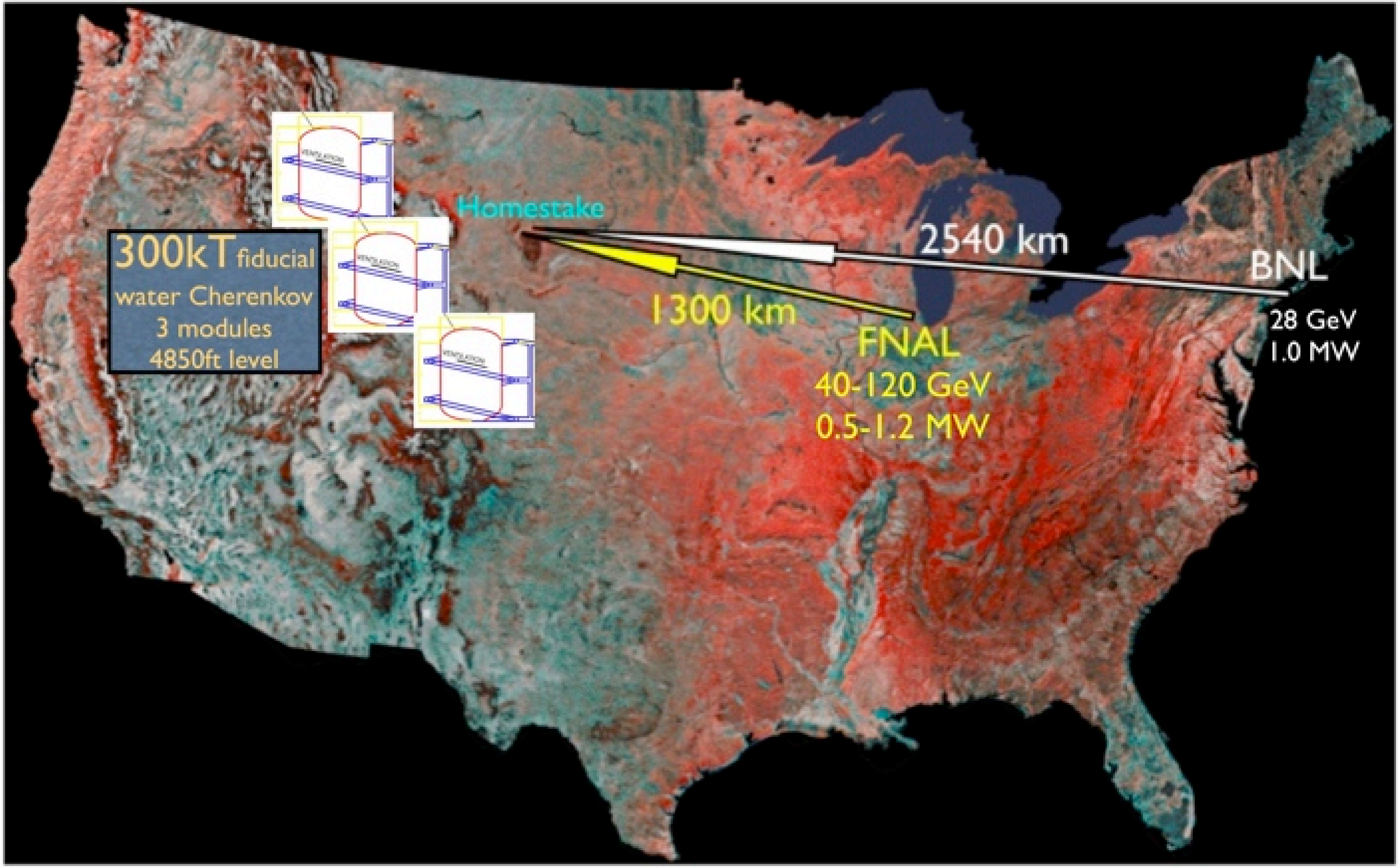
* NNSA will add a high energy high-intensity laser capability to at least one of its major compression facilities in order to observe and characterize the dynamic behavior of high-energy-density matter.

* DOE and NSF will develop a scientific roadmap for the luminosity upgrade of the The Relativistic Heavy Ion Collider (RHIC) in order to maximize the scientific impact of RHIC on High Energy Density (HED) physics.

The plan

- Build a >300 kTon fiducial volume water Cherenkov detector at ~5000 ft depth.
- The detector should have wide dynamic range (5 MeV to 50 GeV)
- Should have good particle identification capability and must lead to a facility with a long life (~30 yrs).

The plan at Homestake



The physics

- Astrophysical sources of neutrinos. In particular, supernova, relic supernova, solar, atmospheric sources.
- Nucleon decay.
- Accelerator neutrino beam with emphasis on CP violation in neutrinos.
- The detector required for all the above has to be very large (~100kton of efficient fiducial mass)

Status of studies

- This talk is not about the physics. I will only talk about the project plan (under progress).
- A large amount of simulation and other material has been collected for the US long baseline neutrino experiment study (joint FNAL and BNL effort). A draft report is being circulated.
- http://nwg.phy.bnl.gov/fnal-bnl

3 elements of detector project

- Cavern excavation
  - Critical for determining size and feasibility
- Photo-multiplier tube production
  - Critical for schedule
- Photo-multiplier installation
  - Drives the technical manpower need.

Backup information

- Rely on SuperK for schedule development
- Rely on SNO for electronics and installation costs.
- PMT cost and schedule information from photonis and Hamamatsu (no actual quotes)
- Information from AUGER on PMT costs.
- Installation details in progress

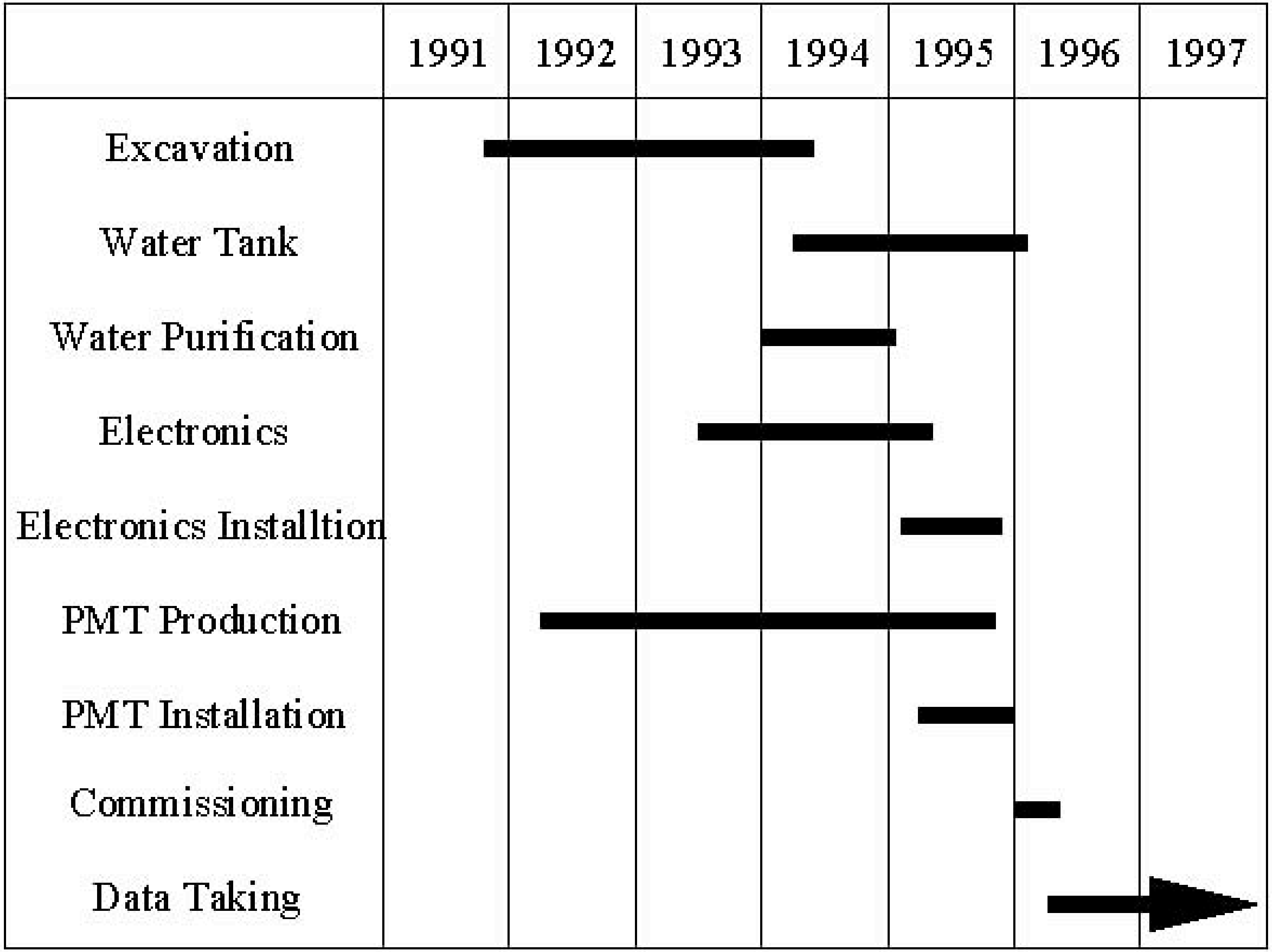
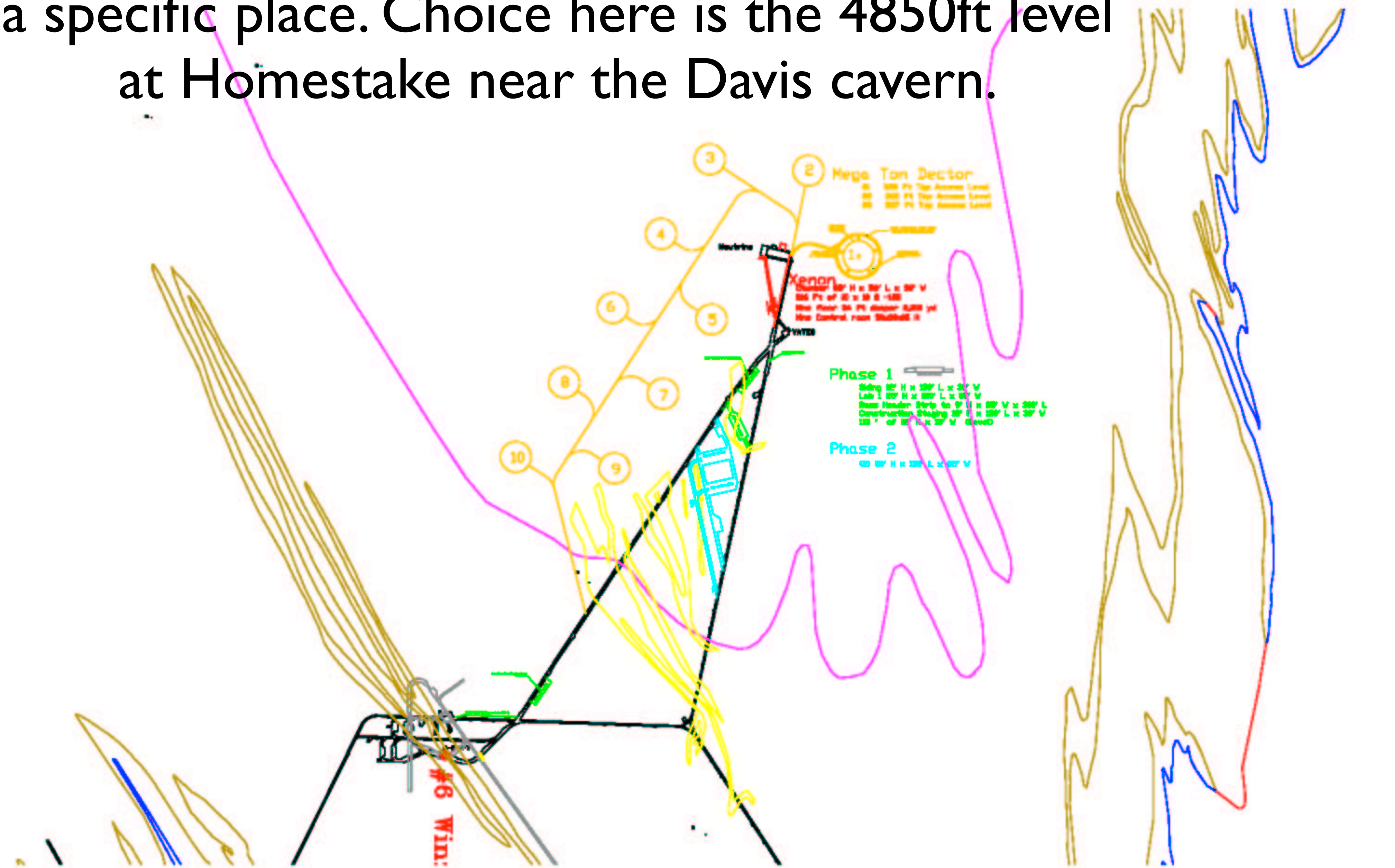


Fig. 3. Super-Kamiokande construction schedule.

Summary cost ($FY07) for 300kT

Cavity construction (30% contingency)	$78.9M
PMT+electronics	$171.3M
Installation+testing	$35.7M
R&D, Water, DAQ, etc.	$8.2M
Contingency(non-civil)	$50.8M
Total	$344.9M

Chamber construction must be estimated for a specific place. Choice here is the 4850ft level at Homestake near the Davis cavern.



Chamber excavation

Labor/Benefits	$19.3M
Mining equipment operations	$4.55M
Supplies	$15.8M
Precast concrete liner	$11.4M
Outside contractor (bore holes)	$0.42M
Plastic liner	$0.79M
Rock removal	$3.18M
Mining equiment	$5.30M
Contingency	$18.2M
Total for 3 chambers	$78.9M

Sanity check: estimate based on former Homestake mine chief engineer's estimate. Cost comes out to be $63/ton, well above to historical costs at Homestake.

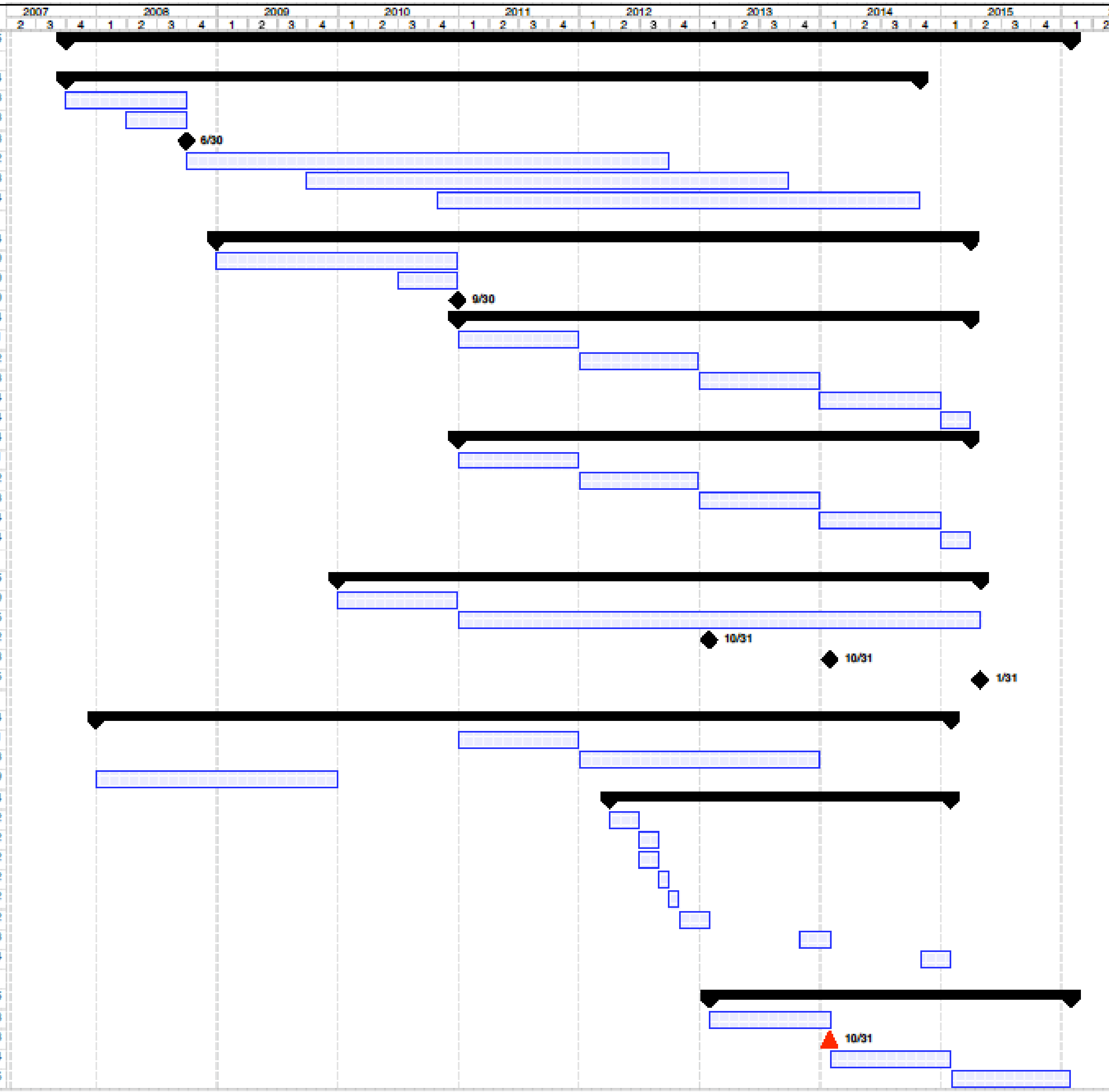
PMTs

	Cost for one
28 cm dia PMT	$933
Installation/PM	$175
Electronics/PM	$127
Cable/PM	$86
Total per PMT	$1317

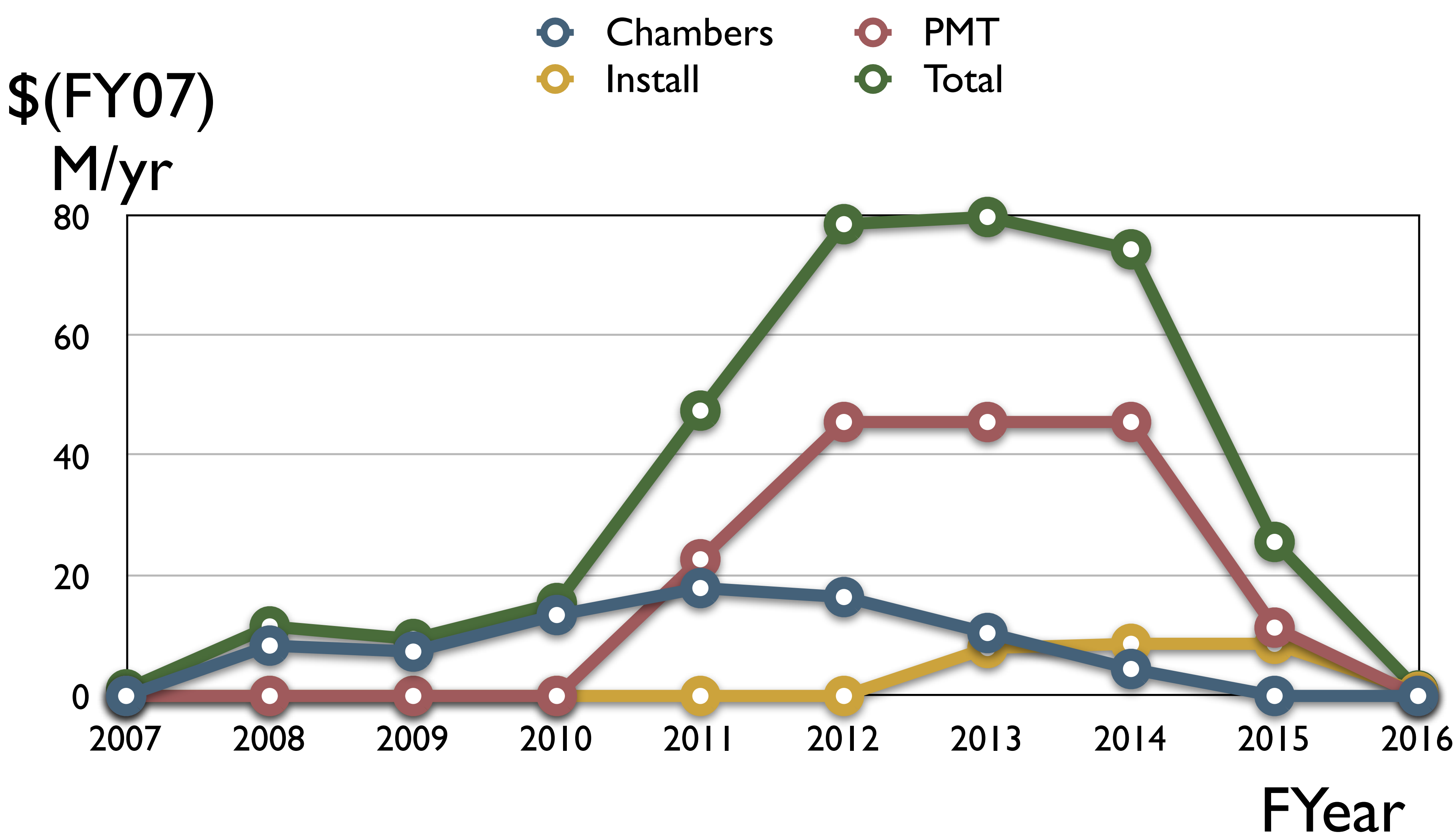
50000 PMTs per 100 kT tank => 25% coverage
Sanity checks: Auger PMT cost $629/each for 5000 units with 9 inch diameter. Base cost additional $175. Other costs have basis with SNO actual costs with adjustments for differences.

Long Baseline Neutrinos + PDK
Schedule No. 2

ID	Task Name	Start	Finish
1	**Long Baseline Neutrinos + PDK**	**7/2/07**	**10/30/15**
2			
3	**Chamber Construction**	**7/2/07**	**7/30/14**
4	Chamber R&D	7/2/07	6/30/08
5	Contract Process	1/1/08	6/30/08
6	Chamber Construction Contract Award	6/30/08	6/30/08
7	Module 1	7/1/08	6/29/12
8	Module 2	7/1/09	6/28/13
9	Module 3	8/2/10	7/30/14
10			
11	**PMs**	**10/1/08**	**12/31/14**
12	PM R&D	10/1/08	9/30/10
13	Contract Process	4/1/10	9/30/10
14	PMs Contract Award	9/30/10	9/30/10
15	**Vendor 1**	**10/1/10**	**12/31/14**
16	Qty 10,000 PMs	10/1/10	9/30/11
17	Qty 20,000 PMs	10/3/11	9/28/12
18	Qyt 20,000 PMs	10/1/12	9/30/13
19	Qty 20,000 PMs	10/1/13	9/30/14
20	Qty 5,000 PMs	10/1/14	12/31/14
21	**Vendor 2**	**10/1/10**	**12/31/14**
22	Qty 10,000 PMs	10/1/10	9/30/11
23	Qty 20,000 PMs	10/3/11	9/28/12
24	Qyt 20,000 PMs	10/1/12	9/30/13
25	Qty 20,000 PMs	10/1/13	9/30/14
26	Qty 5,000 PMs	10/1/14	12/31/14
27			
28	**Testing**	**10/1/09**	**1/31/15**
29	Test Facility	10/1/09	9/30/10
30	Testing of PMs	10/1/10	1/30/15
31	1st Module PMs ready for Installation	10/31/12	10/31/12
32	2nd Module PMs ready for Installation	10/31/13	10/31/13
33	Final Module PMs ready for Installation	1/31/15	1/31/15
34			
35	**Other Equipment**	**10/1/07**	**10/31/14**
36	Calibration Equipment R&D	10/1/10	9/30/11
37	Calibration Equipment	10/3/11	9/30/13
38	Development Labor	10/1/07	9/29/09
39	**Water Purification**	**1/2/12**	**10/31/14**
40	Purchase Order	1/2/12	3/30/12
41	Vendor	4/2/12	5/31/12
42	Shop Conversion	4/2/12	5/31/12
43	Install Water Systems (3 systems)	6/1/12	6/29/12
44	Test Water (to see if suitable)	7/2/12	7/31/12
45	Fill up 1st Chamber	8/1/12	10/31/12
46	Fill up 2nd Chamber	8/1/13	10/31/13
47	Fill up 3rd Chamber	8/1/14	10/31/14
48			
49	**Installation**	**11/1/12**	**10/30/15**
50	Module 1	11/1/12	10/31/13
51	Physics Turn-On	10/31/13	10/31/13
52	Module 2	11/1/13	10/31/14
53	Module 3	11/3/14	10/30/15



Profile



Chambers
PMT
Install
Total
$(FY07)
M/yr
80
60
40
20
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
FYear

Cost plan $M FY07

FY	Chamber	PMT+elect	Install	Total*
2007				1.1
2008	8.4			11.6
2009	7.4			9.5
2010	13.5			15.5
2011	18.0	22.8		47.6
2012	16.5	45.7		78.7
2013	10.5	45.7	8.0	79.9
2014	4.5	45.7	8.7	74.5
2015		11.4	8.7	25.7
2016			0.7	0.91

*Total includes R&D and other items

How to fund it ?

This is only a suggestion meant to provoke discussion.

FY	NSFphsI	NSFphsII	HEP	NUCL	Total
2007	1.1				1.1
2008	11.6				11.6
2009	9.5				9.5
2010	7.0		8.5		15.5
2011	20.		20	7.6	47.6
2012	20.		30.	28.7	78.7
2013	15	5	30	29.9	79.9
2014		30	10	34.5	74.5
2015		20.7		5.0	25.7
2016		0.91			0.91

Summary

- Baseline detector 3 modules each 100 kTon
- Total cost $FY2007: $345M
- First 100kT in FY2014, Full detector by FY2016.
- This is a very preliminary plan. A lot of work is needed to turn it into a “real” plan.